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Mulching and Potassium Relationships in Hass Avocados to Increase Yield and Fruit Size

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ABSTRACT

The Hass cultivar is important to the South African avocado industry as it is preferred by consumers, and is late maturing so filling a niche market overseas. Hass yields, although higher than most other cultivars, are still unacceptably low and a high percentage of fruit are too small to fetch good prices. The application of a thick composted filterpress mulch was investigated as an alternative to composted pinebark, as a strategy to help alleviate stress and increase yield and fruit size. In addition, the effect of potassium on the biennial bearing habit and mean yield of trees was investigated. Trees were evaluated over two years (three harvests) for: yield, fruit size, shoot growth, root growth, root zone temperature, root zone water content, leaf nutrient level, stem circumference and canopy diameter. Average fruit mass from mulched trees increased, whilst number of reject (small) fruit decreased, with a less pronounced biennial bearing pattern being evident when compared to controls. Trees mulched with filterpress produced higher yields and fruit size than all other treatments. Application of 5 kg potassium to trees mulched with filterpress showed a reduced yield but improved fruit size. Addition of 5 kg potassium to unmulched trees significantly increased yield and reduced the number of reject (small) fruit by 13%.

INTRODUCTION

The Hass avocado is preferred by overseas consumers due to its excellent internal keeping quality and superior taste. It is furthermore important to the South African avocado industry as it is late maturing and so fills a niche market locally and abroad. It is common knowledge that Hass trees bear a large number of unacceptably small fruit (Kremer-Köhne & Köhne, 1995). The poor consumer acceptance of these small fruit (Moore-Gordon *et al*., 1997) in a predominantly export orientated market (Cutting, 1993) causes considerable financial losses, estimated to be over R30 million in 1994 (Moore-Gordon and Wolstenholme, 1996).

The problem seemingly increases under stressful growing conditions (Moore-Gordon and Wolstenholme, 1996) and with increasing tree age. The long-term solution to this problem lies in one of two strategies, i.e. to find the physiological mechanism for the random development of small fruit and thereby manipulate the tree through the application of growth regulators or hormones, or to breed new large-fruiting black-skinned cultivars. Both "processes" are time-consuming and so an interim amelioration of the problem through mulching with pinebark has been suggested in the short-term (Moore-Gordon *et al*., 1997). The benefits derived from mulching include increased water and nutrient availability (Gregoriou & Rajkumar, 1984), improved soil structure and porosity (Gallardo-Laro & Nosgales, 1987) and a narrowing of the diurnal soil temperature range (Gregoriou & Rajkumar, 1984). In addition, mulching creates a suppressive environment to the *Phytophthora cinnamomi* root rot fungus, therefore reducing the impact of this phytopathogen (Turney and Menge, 1994). On the whole mulching promotes a healthier, even root growth that not only ameliorates stressful conditions for the roots, but ultimately alleviates stressful growing conditions for the tree as a whole. The highly beneficial effect of mulching with composted pinebark, in both 'Hass' fruit size and especially yield, has been summarized by Moore-Gordon *et al*. (1997).

The current project was commissioned by Mr Werner Seele of 'Cooling' farm, Bruyns Hill, primarily to test the viability of using sugarcane filterpress or filtercake as an alternative mulch to composted pinebark. Pinebark is an expensive mulch, whilst filterpress, which is a waste product of the sugar milling process, is often allocated free of charge to a specified tonnage. Transport to the farm however, is an additional cost. Mr Seele also noted that whenever a large crop had been harvested in the current season, a corresponding large loss of potassium occurred due to removal of the fruit. This was followed by low leaf potassium levels the following season, with an associated loss in yield. Leaves in the following season would again have sufficiently high potassium levels, and a resultant high yield. Mr Seele therefore requested that a potassium trial be superimposed on the mulching trial to determine whether extra potassium additions would have a beneficial effect on fruit size, yield and the alternate bearing habit of the trees.

MATERIALS AND METHODS

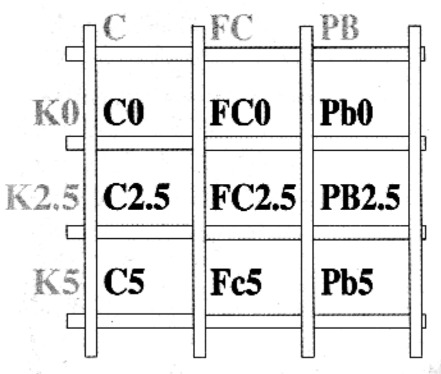
Treatments

The study was conducted at Cooling farm (Mr W.R. Seele) near Bruyns Hill in the Kwazulu-Natal midlands. A block of 72 eight-year-old Hass trees (in 1996) on clonal Duke 7 rootstocks at a planting density of 100 trees ha^{-1} were used. The trees are situated on a South-East facing slope on soils of the Inanda form. Nine treatments were applied (2 trees/treatment/replication) and each was replicated four times (18 trees/replication). All the experimental trees received standard cultural treatment, including weed control and microjet irrigation based on tensiometer measurements.

Treatments are represented as follows:

C = Control
FC = Filtercake/Filterpress
PB = Pinebark
KO = 0 kg Potassium/Tree (K Rate 0)
K2.5 = 2.5 kg Potassium/Tree (K Rate 1)
K5 = 5 kg Potassium/Tree (K Rate 2)

The experimental design was a 3x3 factorial giving the nine treatments applied to eight trees/treatment.



In figures to follow potassium rates are simply referred to as 0, 1 and 2 (e.g. FC1 instead of FC 2.5).

The filterpress mulch was composted for six months prior to application (in October 1996) of a 100 mm thick layer from tree trunk to canopy drip zone. Composted pinebark (Gromed® coarse potting mix) was applied in a similar fashion. Approximately 2.5 m^3 of mulch/tree was therefore applied. The control trees were left "as is" in the orchard, with the natural leaf litter mulch left undisturbed.

Potassium was applied at rates of 0 kg, 2.5 kg and 5 kg active potassium/tree. Applications were done in two split dressings annually in October 1996 and 1997 and January 1997 and 1998. To prevent "chloride leaf burn" KCI was used in the first season, and K_2SO_4 in the second season.

Data collection

Tree diameter and stem circumferences (above and below the graft union) were measured once a year. Shoot flush was measured at monthly intervals from the beginning to the end of the spring flush, by measuring 10 marked shoots on each tree. No pronounced summer flush was noted. Root growth was monitored by visually rating the area covered by white feeder roots, on a scale of 1 to 1 0, under a newspaper mulch layer (Whiley *et al.*, 1988) on the southwest side of each tree to avoid direct sunlight (Moore-Gordon *et. al*. 1996). Leaf samples were taken for mineral analysis to determine the levels of potassium and other minerals over the season. At the end of each season fruit was harvested and fruit count size distributions determined gravimetrically, according to the number of fruit per 4 kg export carton.

Fruit of count sizes above 24 were regarded as rejects since they were not of an exportable size. Fruit was graded as follows:

- Count 10: 366-450 g
- Count 12: 306-365 g
- Count 14: 266-305 g
- Count 16: 236-265 g
- Count 18: 211-235 g
- Count 20: 191-210 g
- Count 22: 171-190g
- Count 24: 156-170 g

Total tree yield was calculated and all the fruit for each tree were weighed in lug boxes and counted, allowing for average fruit mass for each tree and ultimately each treatment to be determined.

Agrometeorological measurements including air temperature, root zone temperature and root zone water content for each treatment, discussed by van Niekerk, Savage *et. al*. (Paper in preparation) were monitored over a period of approximately 18 months.

Thermocouple sensors were used for temperature measurements and were placed at a depth where the mulch or leaf mulch, in the case of the controls, met the soil layer (roughly 70-100 mm). Thetaprobes (Model ML1 from Delta T, United Kingdom) were used to measure soil water content, and were buried horizontally and inserted into the side-profile at approximately the same depth as the thermocouples. All sensors were connected to a datalogger. Only yield and fruit size data are reported in this paper.

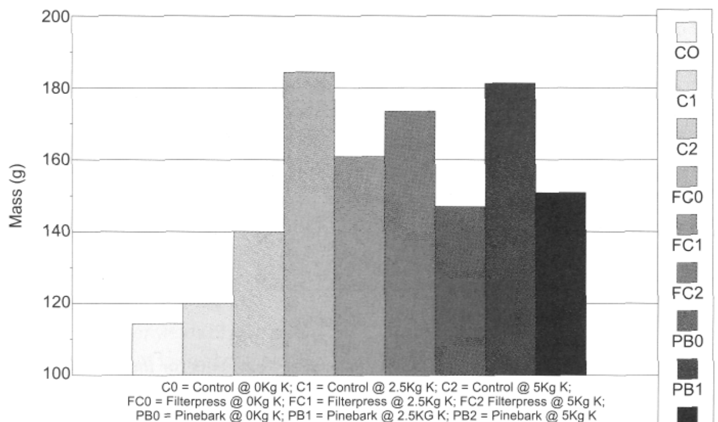


Figure 1A: Average fruit mass in grams for the 1996/7 season for all treatments of mulching and potassium applied

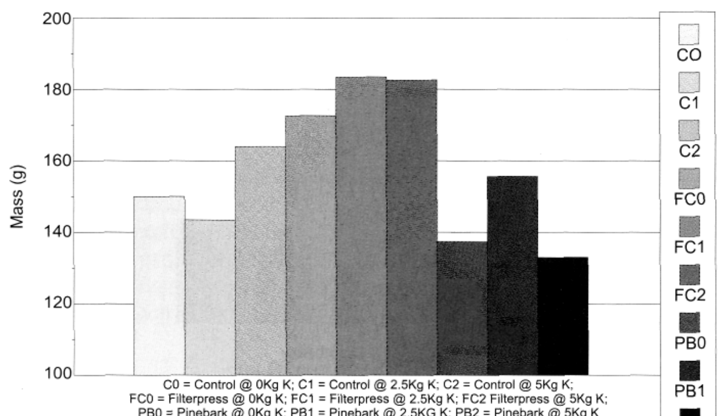


Figure 1B: Average fruit mass in grams for the 1997/8 season for all treatments of mulching and potassium applied

RESULTS AND DISCUSSION

Fig. 1A and 1B show the average fruit mass for the 1996-1997 and 1997-1998 seasons. It is important to remember the treatments for the 1996-1997 season were only applied in October, which is after floral initiation and fruit set. Control trees produced fruit of 115 g for C0 (Fig. 1A), and average fruit mass increased with increasing rates of K. Even so, all fruit were in the above count size 24 category, and hence reject. Nevertheless, this result indicated a potassium deficiency in the orchard, which was verified by orchard soil analyses (data not shown). Control trees produced larger fruit of 151 g for C0 (Fig.1B), with no observable trend in response to rate of K applied. These differences between seasons exemplify the heavy alternate bearing cycle evident in control trees. Without exception, there were significant differences in mean fruit mass between control treatments and filterpress mulch treatments (Fig. 1A & 1B). In the field, filterpress treated trees all exhibited renewed vigour through dramatically improved vegetative growth and produced fruit with an average mass of 183 g (Fig. 1A) for FC0 and 184 g (Fig. 1B) for FC1. However no trend was apparent with an increase in the amount of potassium applied. The lowest rate (FC0) proved to be best in the 1996-1997 season and the intermediate rate (FC1) in the 1997-1998 season, perhaps due to a better nutritional balance/ratio between potassium and the other elements present in the filterpress on application. Average fruit mass of trees supplied a pinebark mulch was greater than that of the controls (as expected), but not as high as fruit from trees mulched with filterpress. Again no observable trend was apparent in response to rate of potassium applied. The relatively poorer performance of pinebark mulched trees suggests that the major limiting factor in this trial was nutritional.

For the data presented in the following graphs it is important to note that the relatively high number of reject fruit was not only size related, but also due to an untimely hailstorm which damaged approximately 20% of the fruit.

Fig. 2A and 2B show the average count size distribution in 1998 of fruit from trees treated with and without either pinebark or filterpress mulch and increasing rates of potassium application. Control trees show a typical fruit size distribution for the Hass cultivar on Cooling farm with 67% of the fruit in the reject range (Fig. 2A & B). Not only were there fewer fruit on the tree, but a large percentage were small fruit. The count size distribution for fruit from filterpress mulched trees was shifted in favour of larger fruit. The distribution peaks at count size 18 for filterpress, with 173 fruit (Fig. 2A) and 192 fruit (Fig. 2B) respectively. A substantial number of count size 16, (97 fruit in Fig. 2A & 104 fruit in Fig. 2B), 20 and 22 fruit were also found. In addition, a decline in reject fruit from the control percentage of 67% to 51% (Fig. 2A) and 41% (Fig. 2B) is evident for the filterpress. The 2.5 kg rate of potassium applied to filterpress thereby producing the lowest reject

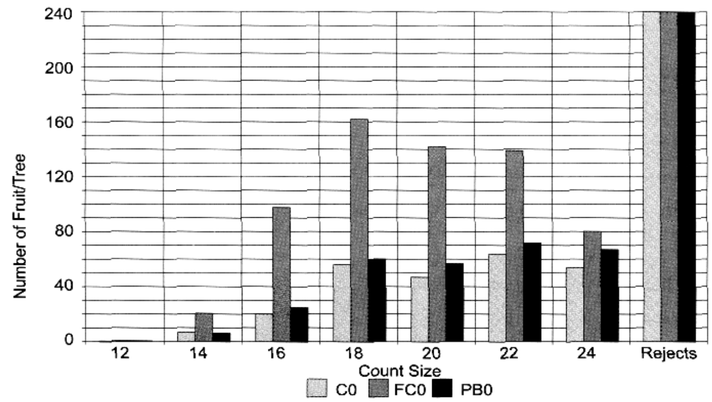


Figure 2A: ***Count size distribution curves for mulch treatments for the 1997/8 season showing the number of fruit harvested per tree in each count size category at a zero rate of potassium applied per tree***

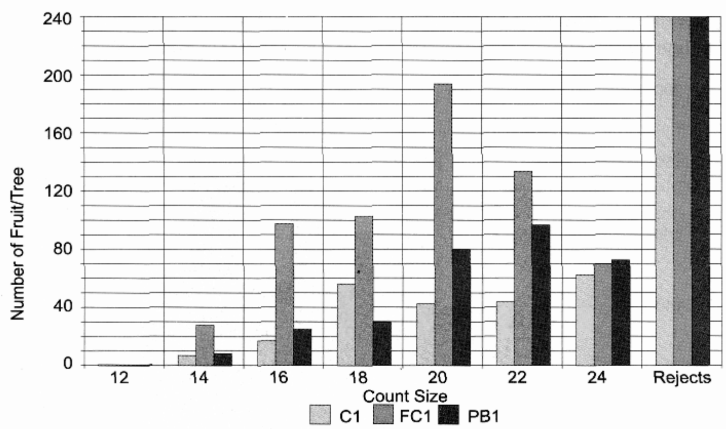


Figure 2B: ***Count Size distribution curves for mulch treatments for the 1997/8 season showing the number of fruit per tree in each count size category on a 2.5 kg rate of potassium applied per tree***

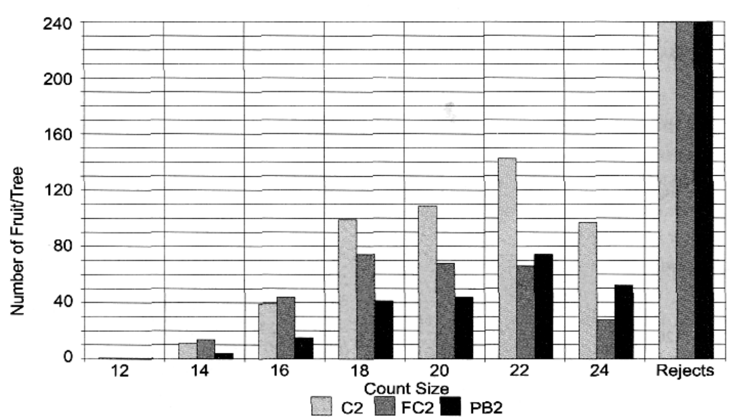


Figure 2C: ***Count Size distribution curves for mulch treatments for the 1997/8 season showing the number of fruit harvested per tree in each count size category at a 5kg rate of potassium applied per tree.***

percentage fruit of all treatments. Not only were more fruit produced by trees mulched with filterpress, but they were generally larger. Pinebark mulch-treated trees produced more fruit than control trees but 66% (Fig. 2A) and 63% (Fig. 2B) of these fruit were in the reject range. In the authors opinion this is largely due to the fact that 1997/8 was a dry season and pinebark often becomes even drier under these conditions thereby limiting root proliferation in the surface layer of the mulch and further disadvantaging the tree from a nutritional point of view. No significant difference in percentage reject fruit is apparent for the potassium treatments applied to the control and pinebark trees.

Fig. 2C shows the average fruit count size distribution from trees supplied 5 kg of potassium. Control trees produced more fruit than other treatments. Of the 1109 fruit, 606 were reject (54%). This was the lowest reject percentage of all control treatments indicating that trees supplied high potassium levels supported more fruit with less small fruit. In filterpress mulch treated trees it is evident that the very high rate of potassium applied in FC2 reduced fruit number and yield, although the majority of fruit was large. Count size peaked at 18 for fruit from filterpress treated trees as opposed to the count size 22 for the control, with 46% fruit being reject. Pinebark treated trees performed poorly at the high rate of potassium with both a low yield of fairly small fruit and 481 of the 699 fruit produced proving to be reject (68%).

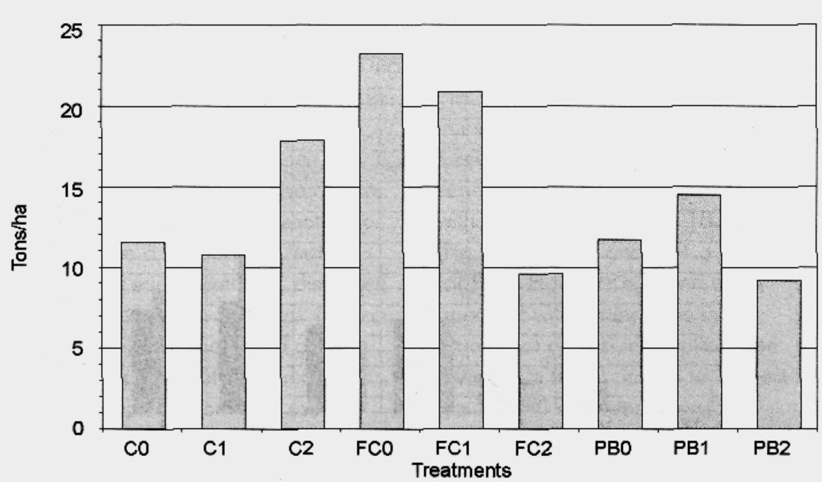


Figure 3: Total Yield in tons ha^{-1} for the 1997/8 season for all applied treatments.

Fig. 3 shows the total yield in tonnes ha^{-1} for the 1997-1998 season.

C0 and C1 produced a relatively low yield of 11.6 and 11.1 t ha^{-1} respectively. By comparison, C2 showed a significantly higher yield (18.2 t ha^{-1}), indicating that the high rate of potassium applied had a positive impact on yield for control trees. FC2 showed a reduced yield (9.8 t ha^{-1}), whilst FC0 and FC1 yielded very well with 23.2 and 21.2 t ha^{-1} respectively. This was significantly higher than for any other treatment indicating that up to 2.5 kg potassium/tree applied to filterpress was advantageous in increasing yield. PB1 yielded significantly more (14.6 t ha^{-1}) than PB0 and PB2. The lowest yield of all treatments (9.4 t ha^{-1}) was exhibited by the PB2 treatment indicating that the high rate of potassium applied became a yield limiting factor when applied in combination with the pinebark mulch.

CONCLUSIONS

Yield and fruit size are determined by a multitude of endogenous and environmental factors. Mulching has been shown to increase fruit size and yield, whilst reducing the number of small, reject fruit. In doing so, a short term solution to improving yield and fruit size in Hass avocado has been achieved. Irrespective of potassium additions, filterpress has been shown to be an excellent mulch for use on Hass avocado due to its inherent nutritional properties, higher water holding capacity and apparent supressiveness to the *Phytophthora cinnamomi* root rot fungus. Of the filterpress treatments, the 2.5 kg potassium treatment (FC1) produced higher yields of larger fruit than were evident for any of the other treatments. The lowest percentage rejects (41 %) was also produced by FC1. Filterpress and pinebark both performed best at the 2.5 kg potassium rate. Control trees produced significantly more, larger fruit at the 5 kg potassium rate, indicating this to be the best rate of potassium for unmulched trees. The relatively poorer performance of pinebark mulched trees as compared to filterpress mulched trees suggests that nutrition was lacking in the orchard. The fact that filterpress is not only a mulch but also an organic fertilizer suggests it alleviated nutritional stress better than pinebark.

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